

NONWOVEN FOR POLYMER MOULDING APPLICATIONS*Field of the invention*

5 The present invention relates to a nonwoven composite, to a process for the production of such a nonwoven composite and to its use as a lining between the body of a moulded article and a decorative facing material borne by the said body.

Background to the invention

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Moulded forms made from thermoplastic polymers have been used for many years as decorative or infill articles, for instance panels, in automotive vehicles, domestic appliances, and the like. Such panels and like components originally had just the polymeric surface itself as the outer face and may have been textured to give a decorative effect. Recently there has been a trend towards laminating a decorative material to the outer surface of the polymer form to improve the effect. These decorative materials can, for example, be textiles, nonwovens or decorative thermoplastic olefin (TPO) films or skins.

20 The trend to providing these moulded forms with decorative surfaces has been particularly strong in the automotive industry in order to match the consumer demand for more "luxurious" interiors; as a result, these decorative moulded components are now common features as door linings, door pillars, dashboard elements, and the like. Additionally, a foam layer, typically polypropylene or polyurethane, may be introduced between the decorative layer and the body of the article; this technique is particularly used when the component is required to feel soft to the touch.

30 In the production of these moulded components there has been a move to applying the decorative surface to the moulded form during the moulding process itself rather than laminating the decorative material to the moulded form as an additional process step after the moulding process; this has cost and productivity advantages. Examples of the moulding techniques used can be found in, for example, F. Beckmann *et al.*, "Fabric back injection: from special process to mass production", *Proceedings of*

VDI *Plastics in Automotive Engineering Conference*, Mannheim (March 1998); I. Adcock, "The pressure is on for a new mold", *Automotive & Transportation Interiors* (May 1997); and United States Patent 5 543 094 (Hara *et al.*). The teaching in these documents is incorporated herein by reference.

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A particular problem in the one-step processes is that, because of the temperatures and pressures used, the decorative surface material can be degraded by being compressed (a textile will be flattened and lose its natural nap, for example) or the thermoplastic polymer used for the body of the form can exude into the decorative
10 surface. If a foam layer is included in the article then this too can be degraded in the moulding process.

The Hara *et al.* patent suggests that these effects can be reduced or eliminated by providing a nonwoven lining between the thermoplastic form and the decorative
15 surface, in this case a fabric. However, the use of needled or spunbonded nonwoven linings as exemplified in the Hara *et al.* patent may still not protect the decorative material adequately because of the inherent non-uniformity of nonwoven fabrics produced by these methods. The nature of the surface of these nonwovens can also create uneven flow patterns within the thermoplastic polymer from which the body of
20 the form is moulded; the surface pattern inherent in these nonwovens can be imposed on the decorative layer.

Summary of the invention

In a first aspect, the present invention provides a nonwoven composite
25 comprising a first fibrous layer in the form of a nonwoven web to which a second fibrous layer is joined by fibre entanglement and further comprising a textile-treating agent selected from silicones, derivatives of silicones and quaternary ammonium compounds, wherein the active level of the treating agent amounts to at least 3% by weight of the solids in the untreated composite .

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In a second aspect, the present invention provides a process for the production of a nonwoven composite in which a second fibrous layer is hydroentangled into a first fibrous layer that is in the form of a nonwoven web, and the resultant structure is treated

with a textile-treating agent selected from silicones, derivatives of silicones and quaternary ammonium compounds.

In a third aspect, the present invention provides an article comprising a moulded
5 body, a decorative facing material and, disposed between them, a nonwoven composite according to the said first aspect of the invention or a nonwoven composite prepared by a process according to the said second aspect of the invention.

In a fourth aspect, the present invention provides a method of manufacturing an
10 article in which a decorative facing material is placed within a mould space, a nonwoven material is located adjacent said material on the side remote from the show surface of the facing material and thermoplastic resin is introduced into the space defined by the mould wall and the surface of the nonwoven material remote from the decorative facing material, wherein the nonwoven material is a composite according to
15 the said first aspect of the invention or a nonwoven composite prepared by a process according to the said second aspect of the invention.

Description of exemplary embodiments of the invention

20 According to the invention, a nonwoven material is used as a lining between (i) a decorative surface or facing material (e.g. a fabric or film) and, if included, a foam layer, and (ii) the thermoplastic polymeric body of a moulded article. The decorative fabric, film or other facing material and, if included, the foam layer are introduced into the mould before the thermoplastic polymer and are thus laminated to the body of the
25 article during the moulding process.

It has now been found that the inherent non-uniformity of the types of nonwovens used as linings in the prior art can be satisfactorily overcome by a process whereby cellulosic and/or other fibres are entangled into a nonwoven and by the nature
30 of the process fill in the nonuniformities.

In certain preferred embodiments of the process a web of cellulosic fibres is hydroentangled into a base or substrate comprising, or consisting essentially of, a

nonwoven web which can, for example, be needlepunched, spunbonded or itself hydroentangled (often termed spunlaced). At this stage the nonwoven/cellulosic web composite (which may also be referred to as a complex or laminate) will be stronger than the original nonwoven but will have lower elongation characteristics and will be more anisotropic, that is the ratio of the cross direction (CD) strength to the machine direction (MD) strength will be less. This ratio, with the CD strength expressed as a percentage of the MD strength, is termed grain. The higher the grain the more isotropic the material. The reduction in elongation and increase in anisotropy that result from the hydroentangling process cause a reduction in moulding performance of the nonwoven in that it cannot stretch so much and cannot adapt itself to the complex shapes of the mould.

However, it has now been further discovered that by treating the nonwoven complex with a textile-treating agent, in particular from the group commonly used as hydrophilic finishes or softening agents, such as a silicone from the group commonly used as softening agents, the properties of the original nonwoven can be restored, or largely so, such that after treatment the elongation characteristics and the isotropy increase to levels that give good moulding performance.

The advantages of the treated, especially silicone-treated, nonwoven complex are several:

- The cellulose or other "second" layer, by "filling in" the structure of the nonwoven base, can give superior protection against polymer penetration and can reduce or eliminate polymer strike-through defects.
- The cellulose or other "second" layer provides a thermal barrier so that the outer decorative fabric, film or other facing material and, if included, foam layer are less affected by heat from the moulding process.
- The incorporation of cellulose and/or other fibres into the nonwoven base can reduce the "memory effect" such that the nonwoven complex shows little or no tendency to shrink or regress to its original dimensions and shape after moulding is complete.

- The cellulose or other "second" layer can also provide an excellent laminating surface so that very smooth surfaces can be achieved with the decorative layer and the surface pattern of the original nonwoven is not transferred to the decorative layer.
- 5 • The silicone or other textile-treating agent, by increasing elongation and allowing fibres to slip against each other, can enhance moulding performance.
- The silicone or other textile-treating agent may act as a lubricant to the thermoplastic polymer flow by reducing surface friction and also polymer shear, as may occur, for instance, at the injection point. This could allow the moulding of
10 larger parts than has been possible with prior art materials.

The first fibrous layer, which may be regarded as the base layer or substrate, is generally formed of fibres of a synthetic polymer (or mixture of synthetic polymers). A suitable nonwoven web can be produced, for example, from a carded web of polyester
15 (e.g. polyethylene terephthalate), polyamide (e.g. poly(hexamethylene adipamide) or polycaproamide, or nylon) or polyolefin (preferably polypropylene) fibres, which can be needlepunched or hydroentangled; or a spunbonded web, e.g. produced from any of the said polymers, can be used. As another alternative, the base layer can be formed from a wet-formed nonwoven, e.g. one made from any of the said polymers. Mixtures
20 of different fibres can, of course, be used. Preferably, the nonwoven web has a basis weight (grammage) of from 20 g/m² to 150 g/m².

The second fibrous layer can be wetlaid or airlaid: it can be deposited as a preformed layer onto the first nonwoven layer, although the formation of the second
25 layer *in situ* on the nonwoven layer, e.g. by deposition of the fibres from a slurry, may come into consideration. Suitable second layers may be formed from pulps of cellulosic fibres, such as wood fibres, or vegetable fibres, e.g. abaca, sisal or jute fibres. Woodpulp is preferred. However, the second layer may comprise or consist of synthetic fibres, especially such fibres of good thermal stability, e.g. polyaramid fibres (such as
30 those obtainable under the trade names "Kevlar" and "Nomex"); polyamide fibres, such as poly(hexamethylene adipamide) or polycaproamide (e.g. nylon fibres); or rayon fibres. Mixtures of different fibres can, of course, be used. Preferably, the second layer has a basis weight (grammage) of from 20 g/m² to 70 g/m².

The fibre characteristics, such as fibre length and denier, will generally be chosen so as to provide webs with good uniformity. Typically, fibre lengths of 10-150 mm, e.g. 20-130 mm, may be used for the first layer. In the second layer, fibre
5 lengths may typically be up to 25 mm, e.g. 2-5 mm, for cellulosic pulp fibres and typically 3 to 25 mm for synthetic fibres. Fibre deniers are preferably low, typically 0.5-6 denier (0.56-6.67 dtex) in the first layer and typically 0.1-3 denier (0.11-3.33 dtex) in the second layer.

10 Prior to the juxtaposition of the second fibrous layer the nonwoven web serving as the first fibrous layer may optionally be cross-stretched or tentered by up to 300 per cent of its original width (heated conditions may be required for extensive cross-stretching), more usually by 5 to 150 percent, and especially by 15 to 80 per cent. Depending on the nature of the fibres, the stretched condition may, if required, be
15 stabilised by heat-setting the web at 150-260°C for a period of up to 10 seconds.

The hydroentanglement may be effected by conventional means, e.g. by directing jets of fluid against the upper web or layer (normally the said second layer) superimposed upon the lower web or layer (normally the said first, nonwoven layer).
20 Thus, the hydroentanglement may typically be carried out by passing the juxtaposed layers, supported on a foraminous belt with the second fibrous layer uppermost, and with a line speed of 5-50 m/min under one or more manifolds providing series or banks of orifices that direct jets of fluid against the said second fibrous layer. The jets are usually columnar jets of water, preferably having a velocity of 40 ms⁻¹ or higher and
25 preferably produced under a pressure inside the manifold of 100 kPa or higher. The orifices may typically have diameters of from 0.05 to 0.25 mm, at a spacing or pitch of 0.25 to 1.5 mm. A process of this type is described in published United Kingdom patent application GB-A-2 220 010 (Nozaki *et al.*, assigned to Uni-Charm Corporation), in published European patent application EP-A-557,678 (Homonoff *et al.*, assigned to
30 Dexter Corporation), and in United States Patent US-A-5 009 747 (Viazemsky *et al.*, assigned to Dexter Corporation), the teaching in these documents being incorporated herein by reference.

As disclosed in EP-A-557,678, the total energy input provided by the fluid jets or streams may be calculated by the formula

$$E = 0.125 \text{ YPG/bS}$$

wherein Y = the number of orifices per linear inch of manifold width (1 inch = 25.4 mm), P = the pressure in psig (pounds per square inch gauge) of liquid in the manifold (1 psig = 6.895 kPa gauge), G = the volumetric flow in cubic feet per minute per orifice (1 cubic foot = 28.32 dm³), S = the speed of the web material under the fluid jets or streams in feet per minute (1 foot = 0.3048 m) and b = the basis weight of the fabric produced in ounces per square yard (1 ounce/yard² = 33.91 g/m²). The total amount of energy, E, expended in treating the web is the sum of the individual energy values for each pass under each manifold, if there is more than one manifold and/or if there is more than one pass. Usually, the total energy input is from 0.07 to 0.4 horsepower-hours per pound (HPhr/lb) (0.414 to 2.367 MJ/kg). Typically, however, the total energy input is less than 0.3 HPhr/lb (1.776 MJ/kg), e.g. is from 0.1 to 0.25 HPhr/lb (0.592 to 1.480 MJ/kg).

Because the elements (webs or layers) of the complex are hydroentangled together other bonding is not required (although additional bonding is not precluded). The basic technology for hydroentanglement could, of course, be readily adapted for other arrangements. For example, it is possible to have fluid jets impinge on both sides of the composite: such an arrangement may be appropriate when the composite comprises a third fibrous layer adjacent the side of the first, base layer that is remote from the said second layer. In such a "sandwich" construction, the third layer may be similar or dissimilar to the second layer, depending on the desired overall properties of the resultant composite.

Either or each of the layers or webs may be single-ply or formed in two or more plies.

The hydroentangled composite, usually after it has been dried, is treated, in accordance with this invention, with a textile-treating agent (which agent may be hydrophilic). Suitable agents may be selected from the class of silicones and silicone derivatives (organosilicones), including siloxane polymers, e.g. poly(dimethylsiloxanes) (PDMS) or poly(monomethylsiloxane); siloxane copolymers (which term includes graft copolymers and block copolymers), e.g. polyether-polysiloxane copolymers (dimethicone copolyols), such as PDMS - (polyalkylene oxide) copolymer

wherein the alkylene oxide is ethylene oxide, propylene oxide or a mixture thereof; and organofunctional siloxanes, e.g. aminofunctional siloxanes. Silicones and derivatives thereof useful as textile-treating agents are known (see, for example, J.C. Salamone (ed.), *Polymeric Materials Encyclopedia*, CRC Press (1996), volume 1, page 215 *et seq.* and volume 10, page 7706 *et seq.*). Silicones useful in the treatment of tissues are also disclosed in WO-A-97/04173, page 8, line 18, to page 9, line 15. Such agents are commercially available, for example the agent marketed as OSI Nuwet 300, or Dow Corning 2-8676 (hydroxy-terminated methylaminopropyl siloxane, 20% actives, emulsion), or Dow Corning 108 (aminoethylaminopropyl dimethyl siloxane).

- 10 Other suitable textile-treating agents include quaternary ammonium compounds, e.g. tetraalkylammonium halides, imidazoline quaternaries, amidoamine quaternaries and ester-quaternaries. Quaternary ammonium compounds and their use as fabric softeners are known (see, for example, Kirk-Othmer, *Encyclopedia of Chemical Technology*, Fourth Edition, Volume 20, Wiley-Interscience (1996), page 739 *et seq.*).
- 15 Quaternary ammonium compounds useful in the treatment of tissues are also disclosed in WO-A-97/04173, page 3, line 22, to page 5, line 29. An example is Varisoft 3690 (methyl-1-oleyl amidoethyl-2-oleyl imidazolinium methylsulfate, aqueous composition, 90% actives). Other agents also come into consideration, e.g. nonionic substituted stearamides.

- 20 The treatment agent may comprise a mixture or blend of suitable compounds.

Usually, the treatment agent is applied in the form of an aqueous composition, e.g. an aqueous solution or emulsion. The treatment agent can, for example, be applied in-line by "padding" or "size press" techniques. Preferably, the level of active ingredients in the treatment agent applied to the nonwoven composite is from 3 to 7%, more preferably from 3.5 to 6.5% and most preferably from 4 to 5.5, by weight of the solids in the untreated composite. Thus, in certain preferred embodiments the nonwoven composite comprises 3 to 7%, more preferably 3.5 to 6.5% and most preferably 4 to 5.5%, by weight of silicone treating agent, as silicone, relative to the total dry weight of the fibres. Nuwet 300, for example, may be applied at a concentration of, say, 80 ml/litre for 100% wet pick-up. After application of the treating agent the composite is usually dried.

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Hydroentanglement was effected by passing the base nonwoven web with the cellulosic web superimposed upon it under ten successive manifolds having pressures within them increasing from 3 MPa to 6 MPa. Each manifold had a nozzle plate having two rows of staggered orifices, of 0.09 mm diameter with a spacing of 1 mm, which directed columnar jets of water at the upper surface of the cellulosic web. The juxtaposed webs were supported on a woven fabric, travelling at about 40 m/min, under which fabric were disposed on a series of vacuum boxes, each in register with a respective manifold, for extracting the water. After hydroentanglement, the resultant

nonwoven composite was dried. The composite was thereafter impregnated with the silicone treating agent in a conventional size press and was dried once more.

The dry tensile strength and the elongation at break were tested in both the machine direction and the cross direction. For comparison, the untreated complex and the needlepunched nonwoven were also tested. The test data were as follows:

Properties	Needlepunched nonwoven	Hydroentangled needlepunched nonwoven and cellulosic web	Complex treated with silicone
Dry tensile strength, MD, N/m	3,130	6,257	3,596
Dry tensile strength, CD, N/m	2,750	4,030	3,061
Dry grain, %	87.9	64.4	85.1
Elongation at break, MD, %	59	39	48.3
Elongation at break, CD, %	100	72	90.5

It can be seen that the untreated complex is stronger but has lower elongation than the nonwoven alone but that the silicone treatment has essentially restored the original properties of the nonwoven to the complex.

Example 2

Using the same materials as in Example 1, except that the carded nonwoven web of polyester, lightly bonded by needlepunching, has a basis weight of 120 g/m², and using the same silicone addition level, 4.1%, the following results were obtained.

Properties	Needlepunched nonwoven	Hydroentangled needlepunched nonwoven and cellulosic web	Complex treated with silicone
Dry tensile strength, MD, N/m	3,628	7,970	6,998
Dry tensile strength, CD, N/m	2,459	4,911	4,036
Dry grain, %	67.8	61.6	57.7
Elongation at break, MD, %	76.6	46.1	74
Elongation at break, CD, %	126	105.9	128.4

This gives similar results to Example 1 but the reduction in strength after silicone treatment is much less.

Example 3

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Using the same materials as Example 1, except that the carded nonwoven web is of 1.6 dtex, 38 mm polyester, bonded by hydroentanglement, and has a basis weight of 45 g/m², and using the same silicone addition level, 4.1%, the following results were obtained.

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Properties	Hydroentangled (spunlaced) nonwoven	Hydroentangled spunlaced nonwoven and cellulosic web	Complex treated with silicone
Dry tensile strength, MD, N/m	2,896	4,198	2,379
Dry tensile strength, CD, N/m	523	1,158	520
Dry grain, %	18.1	27.6	21.9
Elongation at break, MD, %	27.9	23	30.9
Elongation at break, CD, %	164.5	80.7	110.5

Similar effects are obtained with the spunlaced nonwoven precursor as with the needlepunched material.

15 Example 4

A base web of 28 g/m² polypropylene spunlaid nonwoven was hydroentangled to a 60 g/m² wetlaid cellulosic web (3 x 20 g/m² ply). This complex was treated with 4.1% silicone agent (OSI Nuwet 300). The test data were as follows:

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Properties	Spunlaid nonwoven	Hydroentangled spunlaid nonwoven and cellulosic web	Complex treated with silicone
Dry tensile strength, MD, N/m	1,619	2,438	1,797
Dry tensile strength, CD, N/m	901	1,618	911
Dry grain, %	55.7	66.4	50.7
Elongation at break, MD, %	86.2	43.6	59.6
Elongation at break, CD, %	129.6	75.4	106.9

Again, similar results are obtained. This construction is particularly appropriate when the interposed nonwoven complex should be lightweight.

5 *Example 5*

This is the same as Example 1 except that a range of silicone additions has been used.

Properties	Hydroentangled needlepunched nonwoven and cellulosic web complex treated with silicone		
	Silicone level 4.1%	Silicone level 5%	Silicone level 6%
Dry tensile strength, MD, N/m	3,596	4,031	3,871
Dry tensile strength, CD, N/m	3,061	2,675	2,632
Dry grain, %	85.1	66.4	68
Elongation at break, MD, %	48.3	49.4	48.7
Elongation at break, CD, %	90.5	96.3	95.8

With increased silicone addition, the ratio of CD strength to MD strength declines so that the product is less isotropic. When the silicone addition is increased to 6% the elongation decreases.

It will, of course, be understood that the present invention has been described above purely by way of example and that modifications of detail can be made within the scope of the invention.